Diversion Effects on Fish

Issues and Impacts

Prepared by the

CALFED Diversion Effects on Fish Team

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CALFED
BAY-DELTA
PROGRAM

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EXECUTIVE OVERVIEW

An interagency/stakeholder Diversion Effects on Fish Team (DEFT) was formed to address the technical issues related to diversion impacts on fisheries for each the CALFED alternatives. The primary issues addressed were:

- Which species, populations, and life stages are most sensitive to diversion effects under no action and alternatives 1, 2, and 3?
- What degree of benefit and impact will the common programs provide?
- What is the risk and chances of success of species recovery for each alternative?

To evaluate these issues, species teams were formed for salmon, striped bass, and delta smelt. These species were chosen because they represent a range of exposure periods and they are the objects of numerous management and regulatory concerns. There are species that may be affected by changes in delta conditions whose responses may differ from the species analyzed here. The species teams developed matrixes on the effects of a set of impact parameters on the life stages of each species by month for each alternative. The detailed matrixes are described in individual species reports appended, which the reader is strongly urged to review for the details of the evaluations. This report summaries the process, assumptions, modeling studies, information used, professional judgement and the conclusions reached by the teams.

This report and the results should be interpreted cautiously, recognizing the many informational and procedural limitations inherent in these work products. The short time frame provided for this work compelled the team to rely primarily on professional judgement to evaluate the degree to which each relevant factor affects each of the key species. Assumptions had to made that in some cases limited the teams ability to answer the primary issues and included: 1) evaluation of diversion effects on fish populations was confined to the legally defined Delta, Suisun Bay and Suisun Marsh, even thought the CALFED solution area is much larger; 2) evaluations were based on a single operations study for each scenario with no attempt to minimize impacts or maximize benefits, (The next phase of the teams efforts will be to optimize the alternatives.), 3) the common programs will provide benefits with some negative impacts to each of the evaluated species, but the quantification of these benefits is uncertain, and 4) the impacts of water quality and exotics issues have not been evaluated.

The following were consensus professional judgements of the species teams, based on system operations modeling studies and published and unpublished information on individual species biology. Although the team had consensus on a number of assumptions regarding delta species biology, opinions of other scientists on the validity of the assumptions will likely vary from consensus to strong disagreement. The outcome of the assessments is very dependent on these assumptions.

The **salmon** team evaluated relative survival in the Delta of chinook salmon from the Sacramento and San Joaquin basins; Sacramento River races were assessed in aggregate. Survival was estimated monthly in relation to impact parameters considered important to salmon survival in the Delta. For Sacramento River chinook, five composite parameters had the greatest effects on survival; 1) entrainment losses, 2) flows below a Hood diversion, 3) interior-Delta survival, 4) habitat restoration, food supply, and screening of small agricultural diversions, and 5) impacts on adult upstream migration. Common Programs, Alternative 1, and Alternative 3 had similar total impacts, but involved different tradeoffs among benefits and detriments to salmon survival. Alternative 2 was least favorable, largely due to anticipated increases in adult straying and migration delays. For all three Alternatives, Common Programs provided most of the benefit. For San Joaquin salmon, the key composite parameters were 1) entrainment losses, 2) flow at Vernalis, 3) interior-Delta survival, and 4) habitat restoration, food supply, and screening of small agricultural diversions. Alternative 3 offers the greatest benefits for San Joaquin salmon, exceeding the benefits of any alternative for Sacramento salmon. Benefits accrue through reduced entrainment and improved interior-Delta survival.

The **striped bass** team concluded that none of the alternatives are likely to restore the adult population to historic levels (i.e., population of 1.8-3 million). Alternative 3 provides the best potential for partial restoration of the population. Alternative 3 is likely to reduce the entrainment of juveniles at the south Delta export facilities and increase the salvage of those that are entrained. Alternative 3 will likely enhance the transport of eggs and larvae in the lower San Joaquin River by positive flows and also restore Delta nursery habitat. However, both Alternatives 2 and 3 may have negative impacts by decreasing egg and larva transport below the Hood intake. Alternative 2 also has high impacts because of passage problems created for adult fish using the Mokelumne River as a migration route to Sacramento River spawning grounds. Alternative 2 also subjects eggs and larvae to two diversion points. Alternative 1 is likely to increase the entrainment of eggs and larvae at the south Delta export facilities. The common programs have both potential benefits and detriments that were difficult to quantify but are likely to have some net benefit.

The **delta smelt** team concluded that Alternative 3 has the most potential to improve conditions for delta smelt; however, the uncertainty associated with this evaluation is extremely high. The delta smelt team made separate evaluations for wet years and dry years. The No Action Alternative results in a slight worsening of conditions in both year types because of increased diversions to meet increased demand. The Common Programs result in a moderate improvement in conditions in both year types because of hypothesized benefits associated with increases in shallow-water habitat. Alternatives 1 and 2 represented moderate improvements compared to existing conditions but the benefits are derived from the Common Programs rather than changes in conveyance associated with the alternatives. Alternative 1 resulted in a slight decline in value in relation to the Common Programs. Alternative 2 resulted in a moderate decline in the value in relation to the Common Programs. The hydrodynamic effects of Alternative 2 were believed to be a strong negative effect on delta smelt. Alternative 3 resulted in significant benefit to delta smelt because of the combination of the positive effects of the Common Programs and the Team's assessment that the hydrodynamic effects would also be positive for the majority of the population. The degree of benefit from the three Alternatives is very dependent on the Common Programs; thus, different assumptions about benefits of the Common Programs could result in substantially different assessments.

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1. INTRODUCTION

An interagency/stakeholder Diversion Effects on Fish Team (DEFT) was formed to addressed the technical issues related to diversion impacts on fisheries for each the CALFED alternatives. The primary issues addressed were:

- Which species, populations, and life stages are most sensitive to diversion effects under no action and alternatives 1, 2, and 3? When and where are they most affected?
- What degree of benefit and impact will the common programs provide?
- What is the risk and chances of success of species recovery for each alternative?

To provide a base to evaluate the these issues, interagency/stakeholder species sub-teams were formed for salmon, striped Bass, and delta smelt. This report summaries the organization, process, assumptions, modeling studies, information used, professional judgement and the conclusions reached by these species teams and the full DEFT.

Team Organization

Members of the DEFT are listed below under the species team on which they primarily served. Some participated in several teams. Several people contributed to the species teams that are not on the DEFT. They are identified with an (*).

Salmon team
Patricia Brandes (co-chair), U.S. Fish and Wildlife Service
Shelia Greene (co-chair), Department of Water Resources
Serge Birk, Central Valley Project Water Association
Pete Chadwick, Department of Fish and Game
Karl Halupka, U.S. National Marine Fisheries Service
Jim White, Department of Fish and Game
*Jim Starr, Department of Fish and Game
Striped Bass Team
Lee Miller (chair), Department of Fish and Game
Elise Holland, Bay Institute
*Stephani Spaar, Department of Water Resources
*David Kohlhorst, Department of Fish and Game
Kevan Urquhart, Department of Fish and Game
*Don Stevens, Department of Fish and Game
Delta Smelt Team
Dale Sweetnam (co-chair), Department of Fish and Game
Larry Brown (co-chair), U.S. Bureau of Reclamation
Michael Thabault, U.S. Fish and Wildlife Service
*Chuck Hanson, State Water Contractors

<u>*DEFT members not on a specific species team*</u>
Bruce Herbold, U.S. Environmental Protection Agency
Pete Rhoads, Metropolitan Water District Southern California
Michael Fris, U.S. Fish and Wildlife Service
Jim Buell, Metropolitan Water District Southern California
Ron Ott, CALFED

Process

To guide the species teams and to provide a framework for addressing the issues the DEFT developed a list of impact parameters that have direct and indirect effects on the populations in the Delta. Each species team modified the impact parameters listed below to better assess the impacts on their particular specie. The general impact variables are:

- Entrainment
- Hydrodynamics
- Predation
- Handing
- Food Supply
- Shallow/near shore Habitat
- Water Quality (Contaminants)
- Water Quality (Temperature)
- Water Quality (Salinity)
- Agriculture Diversions
- Straying

Each species team evaluated the impacts and benefits on their species against the above parameters for each month of the year for:

- Exiting Conditions
- No Action
- Common Programs
- Alternative 1
- Alternative 2
- Alternative 3

These alternatives are described in the CALFED document, "Programmatic EIS/EIR, Technical Appendix-Phase II Report", March 1998
Sacramento and San Joaquin salmon represent anadromous species with the shortest exposures to delta conditions. Striped bass, an anadromous species, and delta smelt, a resident species, represent species with greater exposure to delta conditions.

The species teams developed matrixes on the effects of the impact parameters on the life stages of each species by month for each alternative. These were used by the teams to address the primary listed above and other issues listed below. The detailed matrixes and interpretations are described in individual species reports in Appendices 1,2 & 3. Species teams reports were review by the DEFT and other stakeholders outside the DEFT.

Other Issues

This report focuses on primary issues 1, 7, and 5. In addressing these three primary issues the species teams also answered several other issues, numbered below. All others except issues 4 and 13 were addressed in the individual species report (Appendices 1,2&3). Issues 4 and 13 will be addressed in the next phase of this teams efforts. The issues are:

1. Which species, populations, and life stages are most sensitive to diversion effects under no action and alternatives 1, 2, and 3? When and where are they most affected?
2. Can diversion effects in the South Delta be offset by habitat improvements and other common program actions?
3. To what extent can alternatives 1, 2, and 3 offset diversions effects as presently configured?
4. To what extent can diversion effects be offset by modifications to the alternatives or by operational changes? (Will be addressed in biological operation criteria white paper.)
5. What is the risk and chances of success of species recovery for each alternative?
6. What increment of protection or improvement for fish species will be provided by other programs such as the Central Valley Project Improvement Act, biological opinions, etc.?
7. What degree of benefit and impact will the common programs provide?
8. What are the direct and indirect effects on fish populations resulting from each alternative and what is the expected response of the populations to these effects?
9. What Sacramento River flow is required below a Hood diversion to protect salmon, striped bass and delta smelt?
10. What survival rate can be expected for striped bass eggs and larvae and delta smelt passing through Sacramento River screen and pumps in Alternative 2?
11. Should there be a screen on the Sacramento River intake of Alternative 2?
12. What are the logical stages for a preferred alternative? (Will be address in biological operation criteria white paper.)
13. What is the range of biological criteria that should be considered in operations of the three alternatives? (Will be addressed in biological operation criteria white paper.)

2. ASSUMPTIONS AND LIMITATIONS

This report and the results should be interpreted cautiously, recognizing the many informational and procedural limitations inherent in these work products. The short time frame provided for this work compelled the team to rely primarily on professional judgement to evaluate the degree to which each relevant factor affects each of the key species. Assumptions had to made that in some cases limited the teams ability to answer the primary issues. The assumptions and limitations are summarized below.

Biological Scope

The team has analyzed the impacts of different CALFED scenarios using the three species that represent types of fish likely to be affected. Some species, such as those that live their entire lives upstream or downstream of the delta are unlikely to be affected by changes in point of diversion in the delta. Other species, such as tule perch or largemouth bass, have life history characteristics that make them much less sensitive to hydrodynamic conditions or entrainment were also excluded. The three species the team examined included Sacramento and San Joaquin salmon to represent anadromous species with the shortest exposure to delta conditions. Striped bass, an anadromous species, and delta smelt, a resident species, represent species with greater exposure to delta conditions. Other species that may be affected by changes in delta conditions, but whose responses may differ from the species analyzed here, include: green sturgeon, white sturgeon, longfin smelt, Sacramento splittail, and American shad. CALFED may need to develop a future analysis to address these species.

Geographic Scope

The geographic scope of the CALFED "solution area" encompasses all of the Central Valley, San Pablo and San Francisco bays, and the near-shore Pacific ocean. The team's evaluation of diversion effects on fish populations was confined to the legally defined Delta, Suisun Bay and Suisun Marsh. Consequently, the team did not incorporate into its evaluation the potential beneficial and adverse effects of actions outside that area. Fluctuations in ocean and bay conditions, salmon and striped bass harvest management, CALFED's Ecosystem Restoration and Water Quality programs that occur outside the delta, and actions associated with the Central Valley Project Improvement Act (CVPIA) are all likely to affect fish populations.

Restoration and recovery of these three species will also depend on CALFED actions outside of the "problem identification area" that the team has addressed. CALFED's actions must also address many issues of greater uncertainty than those addressed, such as offshore harvest. Therefore, the team was unable to assess the degree to which the effects of these delta-based scenarios contribute to overall restoration and recovery. A far more complex and time-consuming analysis would be necessary to integrate the Delta effects we identify, with the broader range of natural fluctuations and human activities that will determine recovery.

The team identified the principal mechanisms by which storage and conveyance will affect these species, when these species are in the Delta. The team assigned relative ranks to summarize it's assessments of the balance of impacts and benefits for each scenario.

Process

Evaluations were based on the team's best professional judgement to the degree of which each relevant parameter affects each key species. The judgements considered empirical relationships between parameters and survival, where such relationships were available. Evaluations were based on operations modeling studies and qualitative assessments of the degree to which water operations, water management facilities, and biological parameters affect the populations of each species. More rigorous quantitative analysis was not possible within the time constraints imposed on this process.

The evaluations recognized the many sources of uncertainty that derive from the limitations of our scientific knowledge about the species and Bay-Delta ecosystem. From an analytical perspective, monthly averaged hydrology was the primary hydrologic parameter used in the analysis. For example, the use of particle tracking model output, which is based on short time-steps, may help reduce this uncertainty.

Sources of uncertainty on biological processes takes a variety of forms and makes any predictions of actual results at the population level extremely problematic. For example, the benefits of shallow water habitat to Delta smelt are not yet well understood. With regard to striped bass, the continuation of historic relationships into the future is unclear due to the many changes in the system. For salmon, the sources of mortality in the Delta are poorly understood. The various sources of uncertainty were acknowledged, identified, and considered to the extent possible in the evaluation

Procedures and Inputs

Evaluations are based on a single operations study for each scenario. There has been no attempt to minimize impacts or maximize benefits. The next phase of the teams efforts will be to optimize the alternatives. The specific CALFED operations studies used for each scenario were: Existing Conditions-558, NoAction-516, Alternative 1 without storage-518, Alternative 1 with storage-609, Alternative 2 without storage-528, Alternative 2 with storage-532a, Alternative 3 without storage-595, and Alternative 3 with storage-567. These runs included meeting the flow requirements for the Vernalis Adaptive Management Plan (VAMP), meeting the 1995 WQCP, and the biological opinions for delta smelt and winter-run chinook salmon. Analyses were based on monthly flows at selected locations in the Delta averaged over all years and averaged over selected dry and critical years. No attempt was made to explore the full range of annual variability

Using the model runs above, each alternative was analyzed by the salmon team with no new storage and with maximum new storage. The delta smelt and striped bass teams analyzed the no new storage alternatives only. The range of storage represents the extremes of existing storage to an additional 6.2 MAF of new storage. Storage between these two extremes would have marked results on the outcome of these evaluations. There was no attempt to minimize impacts or maximize benefits by optimizing storage.

For each alternative, the model runs produced average monthly flows at locations throughout the Delta. Wet and dry year flow summaries were used in the evaluation of impacts of an alternative. In some cases , using average monthly flows and monthly summaries could minimize the actual impacts or benefits of an alternative. The team attempted to account for the model limitations in their evaluations.

Incorporation of Common Programs

The evaluation of the effects of the Common Programs posed particular challenges for this evaluation. For example, at the current programmatic level of development, the distribution of restored/rehabilitated wetland and riparian habitat has not been defined. Different distributions of habitat would benefit different species. However, even if the distribution were clearly defined, our current level of scientific knowledge limits the evaluation of the benefits that would accrue to each species.

There was a broad consensus among the team that the common programs will provide benefits to each of the evaluated species. The quantification of these benefits is, however, not possible at this time. Increasing the amount of habitat will almost certainly increase the potential for survival of each of the evaluated species, but the magnitude of the increase is uncertain. Some potential impacts of the water quality program on striped bass are considered.

Water Quality

Changes in point of diversion would effect a variety of water quality parameters in the Delta. San Joaquin River water carries a significant load of agricultural chemicals, selenium, and other contaminants and nutrients. Sacramento River water generally carries lower loads and carries different metals such as copper, mercury, cadmium and zinc. Delta water directly receives a variety of agricultural chemicals (including herbicides), salts and organic carbon. Contaminant loads and concentrations vary seasonally, vary with hydrology, and can be expected to vary with different points of diversion and changes in operating criteria. The availability and effects of these chemicals on fish populations, and the food web that supports them, are unknown but potentially significant. Impacts may occur through direct toxicity, but are more likely through chronic effects or trophic disruptions. Synergisms of chronic effects with other factors such as disease or reduced growth that prolongs exposure to predators may also result in effects on fish populations. Changes in the point of diversion could also affect the transport of ocean derived salts in the Delta. The DEFT has not attempted to incorporate any of these contaminant effects into the evaluations of fishery impacts , and recommends collaborative efforts of the ecosystem restoration and water quality program elements to address these concerns as part of the plan for implementing the first phase of the CALFED program. A small group of appropriate experts from the water quality team and the DEFT should meet to evaluate these factors and help the DEFT revise the present report.

Exotics

The Bay/Delta is dominated by non-native species. Some introduced species have substantially altered the functioning of ecosystems they have invaded and the team has limited understanding of the new ecological relationships among species. New species will likely continue to arrive and disrupt the biological communities of the estuary in the future. All data and analyses, therefore, that rely on historical relationships may not predict the future but they are the only available basis for analysis. The almost certain arrival of new species in the future may alter the ability of the estuary to support these three species but the group feels it is unlikely that effects of new species introductions would change the performance of the alternatives relative to each other ,in that, species introductions would not fundamentally alter the response of a fish population to basic ecosystem properties such as spawning habitat, streamflow, or hydrodynamics.

3. PRIMARY QUESTIONS

Each of the species team addressed the primary and other issues in their species reports in Appendices 1, 2 and 3. Summary evaluations of the primary questions (1, 7, and 5) for each species follow.

Salmon

1) Which species, populations, and life stages are most sensitive to diversion effects under existing conditions No Action and Alternatives 1, 2, and 3? When and where are they most affected?

The salmon Team evaluated diversion effects in the Delta on San Joaquin basin chinook salmon and an aggregate of all races of Sacramento-basin chinook. All San Joaquin chinook migrate through the south Delta, where they experience direct entrainment, loss in Clifton Court Forebay, and reduced survival associated with unfavorable flow distributions. A much smaller portion of Sacramento chinook are affected by diversions from the south Delta.

Substantial negative effects exist for both groups under existing conditions, and those would persist under No Action and Alternative 1, although direct entrainment losses would be reduced by a small increment under Alternative 1. Under Alternatives 2 and 3, the entire population of Sacramento chinook would emigrate past a screened diversion at Hood, and would be exposed to flow reductions in the Sacramento River downstream of Hood. Adverse effects unique to Alternative 2 would be increased straying and migratory delay of adult salmon returning to the Sacramento basin, due to both attraction to the Mokelumne River portion of the Delta and exposure to a fish passage facility at the Hood diversion. Under Alternative 2, direct and indirect effects in the San Joaquin portion of the Delta would be less for salmon from both rivers. Those effects would be further reduced under Alternative 3.

Fry rearing in the Delta is important to salmon production, especially in wet years. Diversion effects are believed to be greater on actively migrating yearlings and smolts, whether rearing takes place in the Delta or in upstream areas.

7) What degree of benefit and impact will the Common Programs provide?

Much of the expected benefit for salmon would result from restoration of shallow water habitat. However, the actual effect on salmon populations is uncertain. Salmon pre-smolts are particularly likely to use restored habitats. Restored habitats would also be favorable for predators but in the opinion of most salmon biologists the increased cover and food supply should increase salmon survival and provide net benefits. If habitat restoration is successfully implemented along migration corridors for salmon, benefits should be greater than estimated in this analysis. Screening Delta diversions and improved Delta water quality are also expected to be beneficial. Increased spring flows would slightly improve chinook survival in the Delta, in addition to providing upstream benefits. The Water Use Efficiency and Water Transfer programs would increase flexibility in water supply operations, offering some opportunities to shift diversions to times less detrimental to salmon, but such shifts would probably increase impacts on other species. Overall, the Common Programs are unlikely to provide sufficient benefits in the Delta to offset diversion effects fully.

5) What are the risks and chances of success of species recovery for each alternative?

Recovery depends on conditions throughout the life history of salmon. Because the salmon team considered only needs of juveniles and adults in the Delta, the following answers are more appropriate for addressing risks of precluding recovery by significantly adversely impacting one lifestage, rather than addressing the chances of success of species recovery.

No Action - Substantial adverse impacts to San Joaquin chinook in the south Delta under Existing Conditions would increase under No Action due to the increased exports from the south Delta. Although a smaller proportion of the Sacramento chinook are impacted by south Delta exports, substantial negative effects exist for both groups under existing conditions, and those would persist under No Action. The operation studies provided for these analyses assume the Delta Cross Channel gates are closed between November and June to improve survival of salmon migrating down the Sacramento River. The validity of this assumption during November and December was questioned by the salmon team since water quality objectives often are in conflict during low flow periods. The ongoing efforts of the Ops Group to improve salmon survival under Existing Conditions in the face of limited operational flexibility, and the probable decrease in flexibility over time with the No Action scenario, indicate potential for precluding recovery.

Alternative 1- Delta Cross Channel gate closure to improve survival of salmon emigrating down the Sacramento River would continue to be in conflict with water quality objectives during low flow periods. Improved fish screens in the south Delta would provide additional protection, especially for San Joaquin salmon. These benefits would be tempered by the continued need for handling and trucking, but this is less of a risk for salmon than for many other species. Overall, reduced entrainment and benefits from the Common Programs probably would not be sufficient to cause major improvements in salmon production.

Alternative 2- The diversion at Hood would impose several new risks for salmon from the Sacramento system (see response to question 1 above). The salmon team believes that Alternative 2 would pose risks for salmon from the Sacramento system greater than any other alternative, potentially resulting in population declines relative to Existing Conditions. For salmon from the San Joaquin, the combination of improved flow distribution in the central Delta, and benefits from new screens in the south Delta (see Alternative 1), would make Alternative 2 superior to Alternative 1.

Alternative 3- For Sacramento salmon, Alternative 3 would not pose the same risk for upstream migrants as Alternative 2. Other risks of the Hood diversion would be essentially the same as those described for Alternative 2. These risks would result in overall benefits about the same as for the Common Programs. San Joaquin basin chinook have the greatest potential to benefit from Alternative 3. The benefit that would be most certain is the reduction in entrainment losses associated with the large reduction in diversions from the south Delta.

Striped Bass

1) Which species, populations, and life stages are most sensitive to diversion effects under existing conditions No Action and Alternatives 1, 2, and 3? When and where are they most affected?

No Action- Striped bass eggs, larvae, and juveniles are directly impacted by water diversions in the Delta during the first year of life from April through fall, and sometimes during winter. The impact on eggs and young fish occurs from April to July, with further impacts on larger juveniles through summer and fall. Under current conditions, the population is likely to continue to decline in the absence of a stocking program. In recent years, young striped bass abundance has remained low despite higher-than-average delta outflows and low export rates, both of which are conducive to strong year classes in the past.

Alternative 1- Entrainment of eggs, larvae, and juveniles in the south Delta will continue and increase with channel improvements and additional storage. Closure of the cross channel gates through the spawning season from April to June would reduce the diversion of Sacramento River striped bass eggs and larvae but may cause increased flow reversal in the lower San Joaquin River.

Alternative 2- Increased numbers of eggs and larvae could be diverted and entrained from the Sacramento River because fish screens at the Hood diversion would be inadequate to screen these stages. The magnitude of diversion of eggs and larvae from both the Sacramento and San Joaquin rivers, as well as juveniles from the San Joaquin, depends on operation of the facilities. For example, temporary reduction in diversion at Hood during the striped bass spawning season would reduce diversion of eggs and larva from the Sacramento River and provide transport flow to move young bass to the nursery areas downstream. At the Clifton Court diversion, eggs, larvae, and juveniles would be continue to be entrained; more juveniles would be salvaged.

Adults would be attracted by the high proportion of Sacramento water in the Mokelumne River and they would be trapped behind the fish screen at Hood. The feasibility of passing large numbers of striped bass around or over such structures is highly questionable. Adults trapped behind the Hood fish screen would be forced to spawn in the Mokelumne River and most of their progeny would be entrained in the flow to the export pumps. If flow diverted at Hood is a large proportion of the Sacramento flow, as might occur in dry years, more fish would be attracted to the Mokelumne as a corridor to the spawning grounds.

Alternative 3- Increased numbers of eggs and larvae could be diverted and entrained from the Sacramento River because fish screens at the Hood diversion would be inadequate to screen these stages. The magnitude of diversion of eggs and larvae from both the Sacramento and San Joaquin rivers, as well as juveniles from the San Joaquin, depends on operation of the facilities. For example, temporary reduction in diversion at Hood during the striped bass spawning season would reduce diversion of eggs and larva from the Sacramento River and provide transport flow to move young bass to the nursery areas downstream. If diversions are not curtailed entrainment of egg and larva will be high and transport flows will likely be inadequate. Adult migrations would not be affected as for Alternative 2 because the facility is isolated. Because QWEST flows would be improved over existing conditions and less water would be diverted from the south Delta, the team expects less entrainment of striped bass and improvement of nursery habitat in the Delta.

7) What degree of benefit and impact will the Common Programs provide?

The common programs will likely provide some benefits to young striped bass, but these are difficult to quantify. Screening of small Agricultural diversions would reduce mortality of young striped bass. Increasing the amount of marsh habitat for nursery areas adjacent to Suisun Bay and in San Pablo Bay would likely increase survival of young striped bass. Reducing point and non-point sources of toxic chemicals and metals could improve conditions for all life stages to some degree; however, present population impacts of toxicants have not been demonstrated. Reduction of organic input and decreasing turbidity may adversely affect striped bass production.

5) What are the risks and chances of success of species recovery for each alternative?

When and where are they most affected? The adult population is affected by reduced recruitment as a result of early life stage losses. Although there is evidence of density-dependent survival (compensation) it has not been sufficient to maintain the numbers of adults that were historically present. Recovery cannot occur under the No Action Alternative. Alternatives 1 and 2 appear to exacerbate present problems associated with using the Delta as a water export conduit. Alternative 3, while falling short of restoration to historic population levels, would, if operated in a manner which minimized entrainment of young striped bass and provided adequate transport flows, provide the best opportunity for partial restoration of the population.

Delta Smelt

1) Which species, populations, and life stages are most sensitive to diversion effects under existing conditions No Action and Alternatives 1, 2, and 3? When and where are they most affected?

No Action: Larvae and young juveniles are the most sensitive life stages. These life stages are present in the spring and early summer. The major effects occur in the central and south Delta where altered hydrodynamics and entrainment are important. As delta smelt become adults, they migrate downstream to brackish water areas in the fall and winter and are considered less vulnerable to diversion effects. Pre-spawning adults migrating back into freshwater to spawn in the late winter and early spring become vulnerable to entrainment effects once again.

Alternative 1: The same as No Action.

Alternative 2: Larvae and young juveniles are still the most sensitive stages and are still vulnerable at the same times. The major changes in hydrodynamics anticipated with Alternative 2 are believed to be a negative factor for all life stages of delta smelt, but especially these sensitive stages. These negative effects are expected to be most severe in the eastern Delta.

Alternative 3: Alternative 3 was given high benefit because of its positive effects on returning Delta hydrodynamics to a more "natural" condition, meaning the rivers and most channels maintain positive outflows at most times and places. Positive benefits for delta smelt may be high compared to other species because it is the only species to complete its entire life cycle in the estuary.

7. What degree of benefit and impact will the common programs provide?
The delta smelt team estimated that improvement would occur with the common programs. Much of the benefit predicted is due to the creation of additional shallow water habitat of several different types. The effect on delta smelt is uncertain. Much of this uncertainty stems from the scarcity of evidence of the effects of increasing such habitat. Delta smelt use such habitat for spawning but it seems to be of no special importance as rearing habitat. There is no evidence that spawning habitat is a limiting factor for the delta smelt population. While the habitat will also be favorable for predators, the increased spawning habitat and possible increases in Delta primary productivity and food supply were believed to be possible benefits and were assigned benefits even though this is an area of high uncertainty. Screening Delta diversions and improved Delta water quality are also expected to be beneficial.

5. What is the risk and chances of success of species recovery for each alternative?
For the delta smelt team recovery is defined in "The Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes" (Appendix 1). Alternative 1 is not a major change and probably has little influence on probability of recovery. Alternative 2 seems likely to negatively affect probability of recovery. Alternative 3 seems likely to improve the probability of recovery. All of these assessments are subject to the uncertainties already identified above.

4. SUMMARY MATRIX

The reader is strongly urged to read the detailed species reports in the Appendices for the details of the evaluations. In these reports each species teams developed rational and matrixes that scored the effects of the impact parameters on the life stages of each species by month for each alternative. In that process each team used an evaluation scoring scale referenced to a baseline that allowed that team to make relative evaluations between the alternatives for that species. Some set baseline at existing conditions with a score of "0" while others set baseline to pre-water project conditions. These scales were used by the teams to assist in addressing the primary and other issues. The teams did not try to achieve complete comparability in the baselines and scoring of the various species. For this summary report the team's adjusted the scores so that "0" , the baseline, in all cases is existing conditions and +7 is approaching full restoration. A minus score indicates that the alternative is worse than the existing conditions for the particular species. In general, the scores may be further subdivided as follows:

-3 to -1 = decreases in abundance likely (opposite effect of program goals)
0 = abundance is likely to be similar to existing conditions
+1 to +2 = small increases in abundance at best (unlikely to achieve program goals)
+3 to +5 = increase in abundance likely (may achieve program goals)
+6 to +7 = high likelihood that goals of restoration and recovery may be achieved.

Two types of general uncertainty were associated with the evaluation: 1)uncertainty associated with the existing conditions and causes of impacts on the species, and 2)uncertainty associated with the predicted benefits and impacts of the alternatives. Both types were integrated in the uncertainty scores in the tables below. For existing conditions the salmon team felt the causes of impacts on salmon species are well known and the uncertainty scores do not apply. The salmon team also recognized that considerable exists as to causes, but chose to reflect only uncertainty in predicted benefits and impacts in assigning uncertainty scores.

The integrated levels of uncertainty associated with the scores were assigned:

1 = Low uncertainty
2 = Moderate uncertainty
3 = High uncertainty

The following summary matrices show the score for improvement of the species, the uncertainty associated with the score, and a highlight of the benefit or impact for each alternative.

Salmon

Alternatives	Sacramento River Salmon	San Joaquin River Salmon
Existing Conditions	Score: 0 Uncertainty: NA - Interior-Delta survival is low. - Entrainment losses, suboptimal flow below Hood, and losses to Delta agricultural diversions.	Score: 0 Uncertainty: NA -Detriments associated with low interior-Delta survival, insufficient Vernalis flows, and high entrainment losses.
No Action	Score: 0 Uncertainty: 1 - Minor additional detriments did not warrant a change in summary score.	Score: 0 Uncertainty: 1 -Minor additional detriments did not warrant a change in summary score.
Common Programs	Score: +2 Uncertainty: 2 - Improvement would be driven by both increased shallow water habitat (shelter and reduced predation), and improved food supply. - Improved flows and reduction in agricultural-diversion losses also would contribute to improvement.	Score: +1 Uncertainty: 2 - Improvement would be driven by both increased shallow water habitat (shelter and reduced predation), and improved food supply. - Improved flows and reduction in agricultural-diversion losses also would contribute to improvement.
Alternative 1	Score: +2 Uncertainty: 2 - Benefits derived from Common Programs. - Insufficient change from Common Programs to warrant a change in summary score. - Small reduction in entrainment losses.	Score: +2 Uncertainty: 2 - Improved screens in the south Delta would provide a substantial benefit.
With new storage	Score: +1 Uncertainty: 2 - Reduced flow associated with storage considered sufficient to diminish Interior-Delta survival and increased entrainment losses reduce summary score for this option.	Score: +1 Uncertainty: 2 - Increased exports would contribute to increased entrainment and reduced interior-Delta survival. - Improved screens in the south Delta would provide a substantial benefit.
Alternative 2	Score: -1 Uncertainty: 3 - Interior-Delta survival would be improved. - Improvement would be outweighed by reduced flows below Hood, juvenile entrainment losses at the Hood screen, and the barrier to adult upstream migration (increased straying and delayed migration).	Score: +3 Uncertainty: 3 - Improved flow distribution in the interior Delta would increase survival. - Improved screens in the south Delta would provide a substantial benefit.

Alternatives	Sacramento River Salmon	San Joaquin River Salmon
With new storage	Score: -2 Uncertainty: 3 - Reduced flow associated with storage considered sufficient to diminish Interior-Delta Survival and increased entrainment losses reduce summary score for this option.	Score: +2 Uncertainty: 3 - Similar adverse effects as in Alternative 1. - Improved screens in the south Delta would provide a substantial benefit.
Alternative 3	Score: +2 Uncertainty: 3 - Interior-Delta survival would be improved. - Improvement would be outweighed by reduced flows below Hood and juvenile entrainment losses at the Hood screen. - Tradeoff between beneficial and adverse effects yields the same summary score as for Common Programs.	Score: +4 Uncertainty: 2 - Anticipated ~80% reduction in south-Delta exports would reduce entrainment losses and further improve interior-Delta survival. - Improved screens in the south Delta would provide a substantial benefit.
With new storage	Score: +2 Uncertainty: 3 - Minor additional detriments did not warrant a change in summary score.	Score: +4 Uncertainty: 2 - Minor additional detriments did not warrant a change in summary score. - Improved screens in the south Delta would provide a substantial benefit.

Striped Bass

Alternatives	Striped Bass
Existing Conditions	Score: 0 Uncertainty: NA • Major entrainment of young life stages
No Action	Score: -1 Uncertainty: 3 • Major entrainment of young life stages
Common Programs	Score: +1 Uncertainty: 3 • Uncertain benefits of habitat improvements • Uncertain benefits/detriments of water quality improvements • In-Delta screening benefits juveniles
Alternative 1	Score: +1 Uncertainty: 3 • Increased entrainment of young life stages over existing conditions • Decreased mortality of entrained juveniles • QWEST not improved

Alternatives	Striped Bass
Alternative 2	Score: 0 Uncertainty: 3 • Potential increased entrainment of eggs & larvae (north and south Delta) • Transport flows for eggs and larvae possibly decreased and mortality increased • Decreased mortality of entrained juveniles • Improved QWEST • Adult passage problems and detrimental change in spawning location
Alternative 3	Score: +3 Uncertainty: 3 • Potential increased entrainment of eggs & larvae at Hood • Reduced entrainment of eggs, larvae and juveniles from the Delta • Transport flows for eggs and larvae possibly decreased and mortality increased unless strategic curtailments implemented. • Improved QWEST and Delta nursery habitat.

Delta Smelt

	Delta Smelt - Water Year Type	
Alternative	Wet	Dry
Existing Conditions [1]	Score: 0 Uncertainty: 2 - Baseline condition	Score: 0 Uncertainty: 2 - Baseline condition
No Action	Score: -1[2] Uncertainty: 3 - Negative effect because of increased diversion to meet increasing demand.	Score: -1 Uncertainty: 3 - Negative effect because of increased diversion to meet increasing demand.
Common Programs	Score: +2 Uncertainty: 3 - Positive benefit is hypothesized for increased shallow-water habitat. - Positive benefit is hypothesized for consolidation and screening of agricultural diversions.	Score: +2 Uncertainty: 3 - Positive benefit is hypothesized for increased shallow-water habitat. - Positive benefit is hypothesized for consolidation and screening of agricultural diversions.
Alternative 1	Score: +1 Uncertainty: 3 - The Common Programs provide the only positive benefit.	Score: +2 Uncertainty: 3 - The Common Programs provide the only positive benefit.
Alternative 2	Score: +1 Uncertainty: 3 - The Common Programs provide the only positive benefit. - The changes in conveyance and resulting hydrodynamics will negatively effect all life stages.	Score: +1 Uncertainty: 3 - The Common Programs provide the only positive benefit. - The changes in conveyance and resulting hydrodynamics will negatively effect all life stages.

	Delta Smelt - Water Year Type	
Alternative	Wet	Dry
Alternative 3	Score: +4 Uncertainty: 3 - Positive benefits of Common Programs. - Reduced entrainment. - Improved hydrodynamics.	Score: +5 Uncertainty: 3 - Positive benefits of Common Programs. - Reduced entrainment. - Improved hydrodynamics.

[1] Existing conditions for wet and dry conditions are not the same. Existing conditions for dry years are worse than for wet conditions. Do not compare across the columns.

[2] The negative effect for both year types is actually less than a full unit. The -1 simply implies a slight negative effect, in this case only.